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ABSTRACT

This study examined the relative effectiveness of different types of computer feedback (both corrective and noncorrective) on student achievement. A total of 41 students in grades 9 and 10 comprised the two treatment groups. The subjects all interacted with a computer program written by the researcher. The first treatment group received corrective feedback while the second received noncorrective feedback. Pretests, posttests, and post-posttests were administered to all students. There was no significant difference between posttest scores when compared by ANOVA. There was, however, a pattern of significance when the groups were redefined by gender. The females receiving noncorrective feedback had significantly lower posttest scores when compared to the male subjects from either treatment group. This was interpreted as a reflection of gender bias in the schools, since computational ability was needed for the testing and differences in both math achievement scores and attitude towards math still exist between males and females. Close attention should be paid to the type of feedback that students receive since it affects achievement. Since research supports the existence of gender bias in our educational system, computer-assisted instruction (CAI) might be effectively used to overcome this bias by removing the personality of the teacher from instruction, therefore removing gender bias from the schools. Consequently the future of CAI may be the realization of educational equity for all students. A sample run of both treatments and the testing instruments are appended. (37 references) (Author/GL)

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Relative Effectiveness of Corrective and Noncorrective Computer Feedback On Cognitive Learning of Science

A Thesis in

Curriculum and Instruction

by

Carol L. Hodes

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Science

May 1984

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ABSTRACT

Previous studies of computers in education generally documented cognitive learning and compression rather than occurrences in the affective domain. The present study examines the effectiveness of different types of computer feedback since the currently available courseware contains widely variable feedback types.

A total of 41 subjects comprised two treatment groups. The subjects all interacted with a computer program written by the researcher. Treatment group one received corrective feedback while treatment group two received noncorrective feedback. All subjects were ninth and tenth grade students at a public school. All subjects were pre-, post- and post-posttested. There was no significance between posttest scores when compared by ANOVA. However there was a pattern of significance when the groups were redefined by gender. The females receiving noncorrective feedback had significantly lower post-test scores when compared to the male subjects from either treatment group. This was interpreted as a reflection on gender bias in the schools, since computational ability was needed for the testing and differences in both math achievement scores and attitude toward math still exist between females and males.

The treatment received by the subjects in this study did indeed impact their posttest performance. Close attention should be paid to the type of feedback the student receives from instruction that is computerized since this is related to the student's learning. Since research supports the existence of gender bias in the schools, CAI might be used effectively to overcome this bias by removing the personality of the teacher from instruction. It is advocated that the future of CAI may be the realization of educational equity.

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Chapter I

INTRODUCTION

History of Feedback

The word feedback is broadly used in our language today. Nadler (1977) explains that originally the concept of feedback developed in the 1940's and 1950's to deal with information about a mechanical system's output in order to control or adjust future input. In the 1950's and 1960's the concept of feedback was applied to formal social systems and had come to mean knowledge of results (Nadler, 1977).

Knowledge of results (feedback) can be motivating if presented on a regular basis during a work routine and if the subject considers it significant (Locke, Koeppel and Cartledge, 1969). Also knowledge of results can be directive or corrective to help the learner set a performance goal or behavioral intention. In this study the subjects do not verbalize goals. Test performance may be a function of the way knowledge of results is imparted.

Nadler alludes to types of feedback that a subject may receive. First, motivation can be maintained by "providing information which is inconsistent with perceptions or beliefs of individuals" (p. 71). This can raise the anxiety levels of the subject. Providing computer feedback during a tutorial or drill and practice program such as "You loose, Turkey" may be inconsistent with learner expectations in a public educational system. A second motivating technique is to set

up expectations that certain behavior will lead to feedback of a certain type. If computer feedback is more interesting or entertaining when students answer incorrectly, the students may answer incorrectly intentionally and ignore the intent of the computer instructions.

Description of the Problem

The type of feedback the learner receives from a computer program is an integral part of the lesson. Kearsley (1983) writes that in computer based training systems the learner develops a sense of achievement due to receiving feedback and an assessment of progress. The type of immediate feedback is of primary consideration for courseware designers in both traditional and alternative learning situations.

Forman (1982) suggests that educators in general lack knowledge on how to use the computer most efficiently in order to increase the school's productivity. Gleason (1981) summarizes problems now faced by educators, some of which include:

> What are the most effective CAI strategies?
>
> What type of feedback is most effective?
>
> What type of learner interaction is most productive?
>
> Which affective characteristics of the learner are important? (p. 16).

Gleason states that due to the large numbers of significant variables in any learning situation serious researchers are no longer

interested in comparative studies where one group receives traditional instruction and the other CAI. Gleason perceives the need for further research not strictly limited to the cognitive domain.

Description of the Study

Possible feedback types are defined in the literature by both Delp and Eldridge (1982) and Wager (1981). They speculate on the effect of different feedback types without citing research. Other authors write criteria for courseware mentioning good feedback as essential (Bork, 1980; Bork and Franklin, 1983; Cohen, 1983; Gagné, Wager and Rojas, 1981; Gallini, 1983; Garson, 1979; Miller, 1980; Suppes and Macken, 1978). Garson (1979) sees the need to study the effects of courseware on students. The categories of feedback types according to Wager (1982) are used for the purposes of this study. Fifty percent of the subjects will receive noncorrective feedback, either "knowledge of correctness" or "punishment" upon answering incorrectly. The remaining fifty percent receive corrective feedback such as "elaborated" or "reinforcement" (Chapter Three). Upon answering correctly the subject always receives positive reinforcement (Appendix A, Sample Run).

The terms corrective and noncorrective as they refer to feedback are loosely adapted from Skinner (Moskowitz and Orgel, 1969). They are not meant to be the same as positive and negative reinforcement. There is no distinction or relationship sought between learning (posttest scores) and performance at the microcomputer (number of attempts to answer each question). Also the noncorrective feedback is not the same as negative reinforcement. According to Skinner, negative reinforcement, i.e., electric shock, strengthens an

association by its removal. Subjects who received the noncorrective feedback were not receiving any type of physical punishment. Non-corrective feedback varied among three types including knowledge of correctness, occasional silly feedback, meant to be distracting and some verbal 'put downs' that could be interpreted as verbal feedback received by a subject, if the answer was incorrect, helped the subject understand why he or she was wrong. In the strict sense a positive reinforcer is a reward, such as food, which strengthens an association. Corrective feedback, not a reward in itself, may have helped the subject reach a correct answer through providing information. Only upon answering correctly does the subject receive a verbal reward from the computer such as "Way to go, Jane."

In the future educators will not question computerized learning, but they will need to question the type of feedback that the learner is receiving from the computer program. There is no research to help determine whether feedback type influences learning. A study such as this can assist those who design courseware as well as those who evaluate and purchase courseware.

Need for the Study

As early as 1966 Suppes mentioned the need to examine types of reinforcement, how to inform students of mistakes and whether or not different types of students should receive different feedback.

Chapter Two cites examples of comparative studies done to measure cognitive learning, but there is very little research involving the affective domain. Authors call for feedback to be appropriate to the content material and learner. They unanimously

see the need for good feedback. There is much research done on reinforcement verus punishment in behavioral studies, but no research on applications of reinforcement theory to CAI was found.

In the area of retention the authors disagree. Splittgerber (1979) writes that retention is better in traditional teaching situations when compared to retention from CAI. Gleason (1981) takes an opposing stand, stating that retention from CAI is just as good, if not superior to traditional instruction.

Statement of the Problem

This study will investigate the effect of Computer Assisted Instruction (CAI) on ninth and tenth grade students. The program was written by the researcher and involves both the tutorial and drill and practice modes. The problem can best be stated by asking the following questions:

1. Does the type of feedback affect cognitive learning when feedback types are isolated and feedback is systematized and will this effect be a measurable difference on posttest scores?
2. Will there be a difference in post-posttest scores (retention)?

The following questions will also be discussed for other variables:

1. Will there be a correlation between feedback type and time spent at the microcomputer?
2. Does the gender of the subject result in a difference in test scores?

3. Does feedback have a similar effect on all students regardless of I.Q.?

4. Does feedback type have a similar effect on all students regardless of chronological age?

From the two primary questions the following hypotheses were generated:

1. H_0: There will be no significant difference in cognitive posttest scores between the two groups when feedback types are isolated and systematized.

2. H_0: There will be no significant difference in cognitive post-posttest scores between the two groups (retention) when feedback types are isolated and systematized.

Scope and Limitations

Certain limitations of this study limit the generalizability of the findings. All of the subjects were volunteers from study halls at a public school. Subjects were required to have at least two study halls per week that they were willing to relinquish to this study. Due to the voluntary nature of the study a much smaller sample size was obtained than if the students had been offered incentives or required to participate. The return of the informed consent was less than twenty-five percent. Of the 204 forms given to the students (always at their request) only 43 were returned with the necessary signatures. The subjects represented the bottom 85 percent of the student population. There were no gifted students with I.Q. above 130. The I.Q. range was 82-129. This study, as in any learning

situation, has many other variables that were not mentioned. For example, each student brings his or her own motivational level and attitudes toward learning.

Definitions

The terms used throughout the paper are defined below:

CAI - Computer Assisted Instruction: a term used with any instructional application of computers, has recently been categorized into the following:

a. drill and practice - the most common use of CAI in education; not meant to be substituted for the primary instruction.

b. tutorial - the computer instructs the student in some area of knowledge in somewhat the same manner as would a teacher in a one-to-one situation.

c. demonstration - computerized demonstration has greater potential for interactivity than other classroom demonstrations.

d. simulation - imitation of real or imagined systems such as environmental population studies or body systems.

e. games - used for enchancement of a concept or skill; used as a motivational strategy to achieve this goal.

CMI - Computer Managed Instruction: a classroom management system for organization and record keeping for classes and entire school systems.

Courseware - instructional software.

Feedback - information or response given to the learner by the computer immediately following an incorrect response; knowledge of results that is possibly motivating; the following types of feedback isolated for the present study are:

a. corrective - where the learner is given encouragement to try again or more elaborated information concerning the incorrect response

b. noncorrective - where the learner is given only knowledge of incorrectness, verbal punishment or a distractor to an incorrect response.

Positive reinforcement - a rewarding verbal event to strengthen a correct response of the learner.

Chapter II

REVIEW OF THE LITERATURE

Need for Feedback

According to established educational theory, learning should be reinforced via immediate, systematic methods (Chambers and Sprecher, 1979). Nadler (1977) maintains that feedback can affect learners both positively and negatively. He feels that feedback is generally a motivator and cites conditions under which this takes place:

1. The behavior that elicits favorable feedback is perceived favorably by the learner .
2. Require performance that is somewhat of a challenge in order to give the learner a sense of achievement and avoid meaningless feedback.
3. The goal setting process is closely linked to feedback since the learner cannot do this without some knowledge of correctness .
4. Corrective feedback allows the learner to be self-correcting by providing cues.

Whether all lessons need to include intricate explanations to wrong answers depends on the content of the lesson since some things need more explanation. Sometimes being allowed to proceed to the next frame or problem is in itself reinforcing (Robyler, 1981). Also, students need to be provided with the opportunity to work examples

correctly and receive feedback that informs them of a right or wrong answer (Bork and Franklin, 1979). The microcomputer programmed to give reinforcement or feedback is being used effectively as an integral part of an interactive educational environment.

Attributes of the Microcomputer

Much has been written about the advantages of the microcomputer and its potential effect on education at all levels. One of the greatest capabilities is user control, allowing the student to "weave his or her own educational environment" by controlling the rate content or problems are presented (Cohen, 1983). Students do not all learn at the same rate nor do they spend the same amount of time at the learning process. Bork (1980) feels that the computer can make self pacing more practical and convenient than was previously available with other self paced instructional systems. As instruction is individualized and each student learns at his or her own pace the teacher can be free to pursue other activities (Miller, 1980).

Ideal courseware is described as having tailored feedback, frequent reinforcement and availability of remedial loops (Robyler, 1981). Providing this type of feedback and reinforcement time after time can be tedious for a human. The computer is able to do this task better, since the students may need practice and repetition in excess of the teacher's time and patience (Bork and Franklin, 1983). The immediateness of the information to the student is another advantage seen by Miller (1980). Garson (1979) writes that the computer's ability to give immediate feedback is such a strong advantage that it outweighs the disadvantage of a program not allowing student control.

Bork (1980) also states that "the most valuable aspect of the computer in education is that it allows us to make learning interactive" with students as participants rather than spectators. Psychologists agree that the best feedback comes immediately after the event. Bork also points out that feedback can be not only immediate but precisely formulated to help the student.

Gallini (1983) reports that students can be given not only feedback immediately at each step in a lesson sequence but an appraisal of the correctness of their response. If the answer is correct the feedback can provide positive reinforcement and direct the student to the next step in the sequence. When a student misses an item a message is given to help the student proceed or make necessary corrections to solve the problem. The interactivity of such a program is motivating. The computer is a non-threatening, patient tutor. It is better for the student's self-esteem if no one else knows of his or her mistakes, concludes Gallini. Clement (1981) feels that students appreciate both privacy, since only the computer knows of the mistakes, and evaluation that is not based on the student's social relationship with the teacher.

Garson (1979) states that the advantage of computerized drill and practice over a workbook is the ease with which a computer program can be altered or edited. A book, once printed, is much more expensive to update or revise.

Computer Assisted Instruction Lesson Design

Designing Computer Assisted Instruction (CAI) requires the same type of systematized approach used in the design of other types

of instruction material. However the CAI program is exactly what will be taught. The details are not left to the discretion of the teacher as in the other forms of instruction. CAI programs need to examine what is to be taught carefully since there is no room for irrelevant material. Information and questions are to be pertinent. Information needs to be presented in small, concise steps and there needs to be careful control of examples and questions to allow no alternative interpretation of content material. Questions cannot be ambiguous and must be answerable in a simple manner (Steely, 1979).

Jay (1983) stresses five important factors that cognitive psychologists need to account for in good courseware: memory and attention, language and text characteristics, graphics and visual processing, cognitive characteristics of the learner and feedback to the learner (p. 43). Jay's elaboration on the final factor consists of six recommendations: variation of verbal rewards for correct answers (i.e., no overuse of the same phrase), use personalized responses, do not give answers, allow more than one opportunity to be correct, choose responses to incorrect answers carefully and do not issue punishment. Jay has also determined a need for research on these factors.

Wager (1982) reports that consideration needs to be given to different types of feedback. The sufficiencies of feedback are related to the learner and his or her cognitive style. Very elaborate feedback may be inefficient if a simple answer serves the same purpose; however, elaborate feedback may serve to reinforce an answer. Wager also gives a breakdown of possible feedback types such as:

1. knowledge of correctness (yes or no)
2. reinforcement (good job, nice)

3. punishment (stupid, klutz)
4. elaborated (yes, you were right because...
   or no, that is not correct because...) (p. 265).

Delp and Eldridge (1981) write about the range of feedback the computer courseware can contain, from a relatively neutral "sorry, try again" to "ridiculous positive extremes, providing pictures, waving flags, flashing lights, buzzers and music." (p. 4). Response to negative answers also presents problems. For example, they cite a program in which the screen shows a rock falling on a character representing the learner if the learner responds incorrectly too many times. This produces a reverse effect since students err on purpose to see the rock smash the character.

Robyler (1981) and Steffin (1983) both advocate utilization of the Nine Events of Instruction of Gagné and Briggs (1974) when designing CAI. Robyler, in her attempt to define courseware criteria, mentions screen format considerations as well as feedback. Different types of both can be predicted to distract the student from learning. Time taken for disk functions between responses should be minimal and feedback needs to be immediate to be effective. She also recommends avoiding flashing text and other items since these can be distracting and interfere with comprehension.

Also based on the Nine Events of Instruction, Gagné, Wager and Rojas (1981) propose a system for planning CAI lessons. The program should be designed to give either positive reinforcement or corrective feedback to correct an incorrect answer, respectively. If the answer is incorrect the student is informed and given another opportunity to answer the same question.

Documented Learning Via Computer

Studies were found at all grade levels and all content areas. The earliest research that documented learning and achievement took place in the early 1960's at Stanford under the direction of Patric Suppes. Suppes first introduced computers for instructional purposes in 1963 for the purpose of bringing a "rich supplementary curriculum to gifted students." The course was elementary logic aimed at twelve-year-old gifted students. Individualization without constraints led to a wide range of learning and interests. The introductory course was completed by one student in only four weeks, while other students withdrew from the course. Also at Stanford, language teaching was favorably taught, particularly Russian. Plans were made to develop ten to twelve slavic language courses to be offered on a regular basis with a staff of two. At Stanford, teaching loads in some instances have been doubled with the use of CAI without harming the students' achievement (Suppes, 1980).

The first elementary school in the world to have every child working daily at a terminal was in McComb, Mississippi in 1965. These terminals were linked to Stanford via a modem. Results of this experiment were reported to be positive and the school in Mississippi was still making use of computers ten years later. In one year the Mississippi youngsters gained 2.03 grade levels in math computational ability. A similar California group receiving the same supplemental math instruction gained 2.28 grade levels in one year (Suppes, 1980).

Edwards, Norton, Taylor, VanDusseldorp and Weiss (1974) reviewed the effectiveness of many CAI comparative studies. In Waterford, Michigan students receiving supplementary math CAI gained

over non-CAI students. Although the authors failed to cite the time span of this study, differences in gain were .3 grade level for second graders, .5 for third, .4 for fourth, .5 for both fifth and sixth. First grade students who received CAI in reading associated with a project at Stanford reported by Fletcher and Atkinson (1972), gained .6 grade level more on a standardized test than control students at the end of the year.

Vinsonhaler and Bass (1972) summarize ten studies on CAI and write that the novelty of computers may be a factor in some of the studies. They conclude that if this is true we may see a decline in achievement over a period of time. They also perceive the need for more sophisticated CAI.

Many other studies have found that CAI students do better than their non-CAI counterparts (Suppes and Morningstar, 1972). However many studies have also found insignificant differences. For example, Hollen, Bunderson and Dunham (1971) found no differences in achievement comparing CAI lab simulation to traditional chemistry experiments.

In the area of economic and social science education Soper (1974) reviewed twenty-two papers, some of which were comparative studies. A study was done by Dudley, Elledge and Mukherjes (cited in Soper, 1974) where the CAI economic students had mean 19.54 points absolute improvement over the pre-test and the control group had only 8.49; the CAI students first felt forced to use the computer but eventually changed their attitudes toward the positive. Another study by Bonello, Davisson and Jameson at Notre Dame (cited in Soper, 1974) was an academically successful educational experi-

ment involving freshman social science students where CAI supplement was integrated into the course. Absolute improvement was a mean 5.97 points over their counterparts without CAI.

Paden, Dalgaard and Barr (1977) derived these recommendations for the use of CAI from their comparative studies in the area of economics:

1. use the computer to improve study habits
2. highlight important concepts
3. give prompt feedback
4. keep records
5. give pizzaz to the content

A problem is encountered since trying to compare modes of CAI is an "apples and oranges" type of comparison. Drill and practice seems to be a more effective mode for learning than tutorial; however, the studies use drill and practice as supplementary material where the tutorial mode is primarily used as a substitute for the teacher and traditional classroom instruction (Edwards, et al., 1974). They continue by mentioning that the compression of learning time in CAI studies has been shown mostly in studies involving the tutorial mode. Kearsly (1976) reports that attitudes may be a factor in reducing learning time. Ability also seems to be a factor in CAI learning. The Suppes studies seemed to indicate that lower ability students achieved greater gains. Long-term retention seems to be better for traditional instruction than CAI according to Splittgerber (1979). However, Gleason (1981) disagrees.

Support comes from all content areas and grade levels that significant learning is achieved by use of CAI in either drill and practice or tutorial modes. Actually, instructional media chosen as the delivery system for content material should be chosen because its

unique attributes make it the best mode of delivery for that type of information. Good instructional design should be generic to all instruction. Those attributes that need to be considered when planning the use of microcomputers are those that affect learning outcomes. The type of immediate feedback is certainly one of the most important aspects of CAI lesson design. In the future whether instruction is computerized or not may not be important, but the type of reinforcing feedback received will be recognized as an integral part of the criteria for good CAI design.

Chapter III

EXPERIMENTAL DESIGN

Description

As schools acquire microcomputer courseware for instructional purposes, teachers, coordinators and media specialists need to take a critical look at the type of feedback that the learner will be receiving. In the process of evaluating many of these programs it has become apparent that the type of feedback can vary widely. One type of feedback, noncorrective, may constitute a distractor with which the learners interact upon answering incorrectly during the program. Another type of feedback, corrective, directs the learner to the error and encourages the learner to try again. Courseware that contains non-corrective feedback may make inefficient use of the learner's time. The corrective type of feedback is advocated by the literature, but does not seem to be substantiated by research findings. As schools consider courseware for purchase, the type of feedback and its potential effect on the learner needs to be considered in order to justify its acquisition.

The Problem

Therefore the problem is to compare two treatment groups where the independent variable is microcomputer feedback. The positive feedback is controlled and will be identical in both treatments.

Only the feedback received upon answering incorrectly is varied. The noncorrective feedback is designed to have the student interact with it rather than the content of the lesson:

a. It identifies the incorrect response as wrong.

b. No correction is offered to the student.

c. It asks the student for additional input or gives no direction and on occasion may include a 'put down' to the student.

The other type of feedback, corrective, encourages the student to try again:

a. It also identifies the incorrect response as wrong.

b. It gives the student a corrective procedure.

c. It maintains supportive encouragement for the student to try again after the corrective procedure.

The information is presented in an identical format in both programs. The only difference between the two treatments is that upon answering incorrectly the type of feedback will vary. A comparison of the pre- and posttest scores of these two treatment groups may signify a difference in cognitive learning as a result of feedback differences. The subject's behavior is not being otherwise considered or observed. Since both of these feedback types are characteristic of commercially produced courseware, the purpose of this study is to determine if either of these feedback types is better for learning and encouraging efficient use of student time, school time and funds.

Design: Choice of Groups

The subjects may not be chosen entirely at random since a true random sampling would detract from the normal school schedule. The students were eligible if they met the following criteria:

1. The student has a study hall when the researcher/teacher is not teaching
2. The student has returned an informed consent form signed by parent or guardian.

All students who met the above criteria had an equal chance of being chosen for participation in the study.

The subject population consisted of ninth and tenth grade students enrolled at the Intermediate High School in State College, Pennsylvania, since this is where the researcher/teacher was also employed. There were no prerequisite skills. The age range was from 13 to 16. Care was taken to insure that normal school routine would not be interrupted. The research was carried out in an established educational setting, involving normal educational practices with which the students were familiar in order to help insure validity of test results. Data were recorded so that subjects could not be identified. No names were recorded on the testing instrument or in the computer. The subjects were assigned randomly to the two groups. Each group consisted of a minimum of 20 subjects.

The computer program was planned to represent the Nine Events of Instruction defined by Gagné as opposed to focusing only on feedback and questioning (Gagné, Wager and Rojas, 1981). Figure 1 on the following page is a summary chart of the events of instruction; external events which support the internal ones.

Internal Learning Process	External Instructional Event
1. Alertness	1. The subject's attention is on the screen
2. Expectancy	2. Informing the learner of lesson objectives
3. Retrieval to working memory	3. Stimulating recall of prior learning depends on what they have previously learned
4. Selective perception	4. Presenting stimuli with distinctive features
5. Semantic encoding	5. Self-paced, guided learning
6. Retrieval and responding by computer input	6. Eliciting performance as the computer asks for input
7. Reinforcement	7. Providing informative feedback as the independent variable
8. Cueing retrieval	8. Assessing performance on the posttest
9. Generalizing	9. Enhancing retention and learning transfer by solving number dependent problems

Figure 1: Internal Processes Of Learning And the External Events that Are Used To Support Them[a]

[a]Adapted from Gagne, Wager and Rojas, "Planning and Authoring Computer Assisted Instruction Lessons," Educational Technology, 10/81, p. 19, Table 1.

Therefore this computer program was designed to provide external support for learning content. The independent variable was supplied for both treatments. Noncorrective feedback was supplied to fifty percent of the subjects, for example:

"No!",

"Way Off!", and

"No Way! You get 10 lashes with a wet spaghetti!"

Corrective feedback was supplied to the remaining half, for example:

"Not Quite, read the question again.",

"No. Look at the formula again.", and

"No. Try a higher temperature."

For all subjects the program is designed to:

1. be self-paced
2. avoid too much text on the screen at one time
3. provide the subject with instructions that are clear and direct.

The resources can be thought of as the subjects, the researcher/teacher and the school media center (a corner of the library where six microcomputers are kept).

Procedure

The subjects were pre-tested on paper in their respective study halls one or two days prior to receiving the computer treatment. A day or two before the computer treatment, the researcher/teacher explained a little about the study and administered the pre-test. The subjects were told:

1. that this is a simple computer program where they will sometimes be able to press the space bar to go on
2. at other times they will be asked to type in answers in the form of numbers.

They were not told anything about the type of feedback that they could receive. After the program was finished they were each tested. To test retention after two weeks the subjects were retested with the post-test. All of these tests were done without writing their names anywhere on the page. Since there was a need to cross match the tests, a four digit code of the student's design was used for the purpose of matching. The four digit code originated with the student, was recorded on half of a 3x5 index card and remained in the possession of the student. After the computer treatment and posttesting were completed the student was escorted back to study hall. The retesting also took place in the study hall.

Test Description and Validity

All testing was completed within three weeks, before the end of October, 1983. For testing instruments, see Appendix B. All subjects received the same tests. Multiple choice and matching questions were used for the pre- and posttests since these are both ojbective types of test questions and the scoring could be objective. To correctly answer the matching questions the subject correctly recognized a relationship. This type of instrument yields empirical data concerning effectiveness of computer feedback in learning on

which decisions can be based (Hannum and Briggs, 1982). Evidence of learning was the gain over the pretest score. This was done to neutralize the effect of preknowledge on the scores.

Behavioral objectives of the CAI lesson are congruent with the tests (Appendix B). Each objective is followed by corresponding test questions. Behavioral objectives of the CAI lesson are as follows:

The student will be able to:

1. determine the correct uses of Centigrade and Fahrenheit temperature scales (questions 1-3).
2. use the formula C=5/9(F-32) to convert Fahrenheit to Centigrade (questions 4-6)
3. use the formula F=9/5 C+32 to convert Centigrade to Fahrenheit (questions 7-9)
4. determine which formula is appropriate to a particular temperature conversion (questions 1-12).

Reliability of the pre- and posttests was determined by the Split-Half method. The coefficients were .543 for the pretest and .542 for the posttest. To estimate reliability of the scores based on the full length test the Spearman-Brown formula was utilized (Gronlund, 1981). Reliability on the full test was .7038 for the pretest and .7032 for the posttest.

Computer Treatment

The content area of the computer program was temperature scales and was stored on a 5¼ inch floppy disk. The constant consists of the instructional sequence which covers the content

material. The computer program is written in BASIC for the Apple II computers owned by the school. The format of the computer program is (for sample computer treatment see Appendix A):

1. The subject sees a main menu and is instructed to choose the first of the choices first and then to proceed to 2, 3, 4 and 5 until the program is completed
2. The subject proceeds at his or her own pace since a "Press spacebar to go on" subroutine has been used. Where this subroutine has not been used there is a request for input from the subject in the form of typing a number or answer before the program proceeds
3. The subject has the option of a remedial sequence and can return to any part of the program to review if he or she wishes since the program returns to the main menu after each part (see Figure 2 on next page).

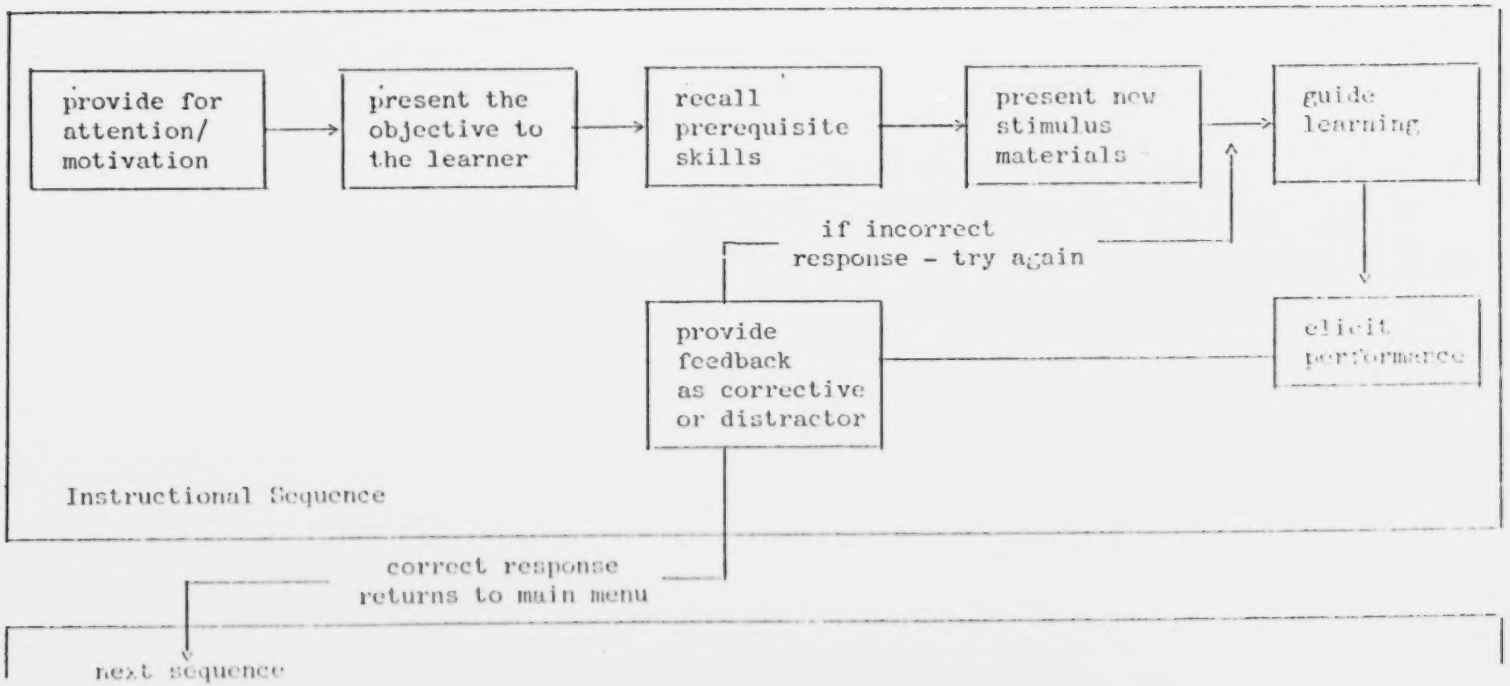

Figure 2: Events of Instruction Paradigm For a Branched Tutorial Program[a]

[a]Gagné, Wager and Rojas, 1981, p. 20

Chapter IV

RESULTS

The review of the literature on computer feedback established the recommendation that feedback should be corrective, reinforcing and nonthreatening, but evidence in favor of this was not available. The fact that this type of feedback was widely advised would cause us to expect a certain outcome in the present study. However, the hypotheses were stated in terms of the null H_0 initially. Because of the lack of evidence in the literature concerning the effects of computer feedback it was assumed that all types of feedback would affect all students equally. A motivated hypothesis was also stated to clarify the hypothesis testing process.

Statement of the Hypotheses

1. H_0: There will be no significant difference in cognitive posttest scores between the two groups when feedback types are isolated and systematized.

   H_1: Posttest scores as evidence of learning are related to feedback type.

2. H_0: There will be no significant difference in cognitive post-posttest scores between the two groups (retention) when feedback types are isolated and systematized.

   H_1: The post-posttest scores (retention) are related to feedback type.

Data Collection and Analysis

There were two treatment groups; one received corrective feedback (group one) and the other received noncorrective feedback (group two). A total of forty-one ninth and tenth grade students voluntarily participated, of which twenty-one were males and twenty were females. Subjects were all given a series of three tests: Pretest, posttest and post-posttest. The highest possible score on all tests was a twelve. Descriptive statistics were computed and appear as Tables 1, 2 and 3.

All test scores were analyzed using analysis of variance (ANOVA). The two treatment groups were redefined into two additional groups based on gender, to be further discussed in Chapter Five. The lack of significant difference in the pretest scores denotes homogeneity of the treatment groups (Table 4), lending validity to the study. Therefore any resulting significant differences may be attributed to the treatment.

Tests of the Hypotheses

1. H_0: There will be no significant difference in cognitive posttest scores between the two groups when feedback types are isolated and systematized. Let $T=\bar{x}$ of treatments. H_0: $T_1-T_2=0$

   H_1: Posttest scores as evidence of learning are related to feedback type. H_1: $T_1-T_2\neq0$. Rejection rule: reject H_0 if $F>F_{table}$ for degrees of freedom 1 and 39 (alpha =.05). $F_{table}=4.09$ while $F=.1989$ (NS). H_0 is retained. Refer to Table 5

2. H_0: There will be no significant difference in post-posttest scores between the two groups (retention) when feedback types are isolated and systematized. Let $T=\bar{x}$ of the treatment groups. H_0: $T_1-T_2=0$

H_1: The post-posttest scores (retention) are related to feedback type. H_1: $T_1-T_2\neq 0$. Rejection rule: reject H_0 if $F>F_{table}$ for degrees of freedom 1 and 39 (alpha =.05). $F_{table}=4.09$ while $F=.7257$ (NS). H_0 is retained. Refer to Table 6.

Table 1

MEAN AND STANDARD DEVIATION

Corrective Feedback
Treatment Group One

	Total Group 1		Male		Female	
n	21		8		13	
	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.
Pretest	6.76	2.65	7.375	2.9246	6.3846	2.6312
Posttest	8.24	2.16	9.75	1.5811	7.3077	2.0569
Post-posttest	7.6667	2.606	8.75	3.1053	7.00	2.2361
Age in months	178.2	6.948	174.25	5.3327	174.7692	20.3353
I.Q.	111.56	14.7769	112.375	11.8435	102.8462	14.4329
Time	17.95	4.065	15.625	2.7742	21.2308	6.0849

Table 2

MEAN AND STANDARD DEVIATION

Noncorrective Feedback
Treatment Group Two

	Total Group 2		Male		Female	
n	20		13		7	
	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.
Pretest	5.7	2.1703	5.9231	2.6602	5.2857	1.1127
Posttest	7.95	1.8567	8.7692	1.6909	6.4286	1.2724
Post-posttest	7.0	2.2583	7.3846	2.4677	6.2857	2.9277
Age in months	179.8	42.2955	178.3692	7.2369	182.57	4.8305
I.Q.	106.6	10.7985	109.6923	9.8943	100.5714	7.2309
Time	18.15	5.9413	16.7692	4.9691	20.7143	7.1114

Table 3

MEAN AND STANDARD DEVIATION

Total Sample

	Total Sample		Total Female		Total Male	
n	41		20		21	
	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.
Pretest	6.2439	2.5177	6.0	2.2478	6.4762	2.7189
Posttest	8.0976	2.047	6.85	2.0333	9.0476	1.6272
Post-posttest	7.3415	2.6326	6.75	2.4468	7.9048	2.7369
Age in months	178.8732	6.7786	177.3	16.7649	176.8	6.6904
I.Q.	106.7805	12.024	102.05	12.2194	110.7143	10.4697
Time	18.3802	5.1569	21.05	6.2784	16.3333	4.223

Table 4

ANOVA SUMMARY TABLE: PRETEST SCORES

Source		df	SS	MS	F	Critical Value p<.05
Group 1 x Group 2	SS_{bg}	1	11.551	11.551	1.6562	4.0988
	SS_{wg}	39	272.01	6.9746		
Group 1: Male x Female	SS_{bg}	1	4.8576	4.8576	.6456	4.38
	SS_{wg}	19	142.9519	7.5238		
Group 2: Male x Female	SS_{bg}	1	1.8483	1.8483	.3603	4.41
	SS_{wg}	18	92.3517	5.1307		
Group 1 Females x Group 2 Females	SS_{bg}	1	5.4931	5.4931	1.0923	4.41
	SS_{wg}	18	90.5069	5.0282		
Group 1 Males x Group 2 Males	SS_{bg}	1	10.44	10.44	1.3699	4.38
	SS_{wg}	19	144.7981	7.621		
Total Males x Total Females	SS_{bg}	1	2.323	2.323	.3606	4.098
	SS_{wg}	39	251.238	6.442		
Group 1 Males x Group 2 Males x Group 1 Females x Group 2 Females	SS_{bg}	3	18.2601	6.0867	.6555	4.35
	SS_{wg}	37	343.5897	9.2862		

Table 5

ANOVA SUMMARY TABLE: POSTTEST SCORES

Source	df		SS	MS	F	p
Group 1 x Group 2	SS_{bg}	1	.8504	.8504	.1989	
	SS_{wg}	39	166.76	4.2759		
Group 1: Male x Female	SS_{bg}	1	29.5404	29.5404	.8239	
	SS_{wg}	19	681.2692	35.8563		
Group 2: Male x Female	SS_{bg}	1	24.928	24.928	10.1926	<.01**
	SS_{wg}	18	44.022	2.4457		
Group 1 Females x Group 2 Females	SS_{bg}	1	4.1587	4.1587	.1136	
	SS_{wg}	18	658.7913	36.5995		
Group 1 Males x Group 2 Males	SS_{bg}	1	4.7638	4.7638	1.7471	
	SS_{wg}	19	51.8077	2.7267		
Total Males x Total Females	SS_{bg}	1	.8504	.8504	.1989	
	SS_{wg}	39	166.76	4.2759		
Group 1 Males x Group 2 Males Group 1 Females x Group 2 Females	SS_{bg}	3	25.3298	8.4433	2.3478	
	SS_{wg}	37	133.0604	3.5962		

*p.05=4.41
**p.01=8.29

Table 5, Continued

Source	df	SS	MS	F	p
Females, Group 1 x Males, Group 2	SS_{bg} 1	12.4685	12.4685	.4379	
	SS_{wg} 24	683.3846	28.4744		
Females, Group 2 x Males, Group 1	SS_{bg} 1	41.1857	48.1857	19.6741	p<.01**
	SS_{wg} 13	27.2143	2.0934		

*p.05=4.67
**p.01=4.07

Table 6

ANOVA SUMMARY TABLE: POST-POSTTEST SCORES

Source		df	SS	MS	F	Critical Value p<.05
Group 1 x Group 2	SS_{bg}	1	4.5529	4.5529	.7257	4.098
	SS_{wg}	39	244.6667	6.2735		
Group 1: Males x Females	SS_{bg}	1	15.1667	15.1667	1.0384	4.48
	SS_{wg}	19	277.5	14.6053		
Group 2: Males x Females	SS_{bg}	1	5.4945	5.4945	.6162	4.41
	SS_{wg}	18	160.5055	8.917		
Group 1 Males x Group 2 Males	SS_{bg}	1	9.2327	9.2327	.9988	4.38
	SS_{wg}	19	176.5769	9.2935		
Group 1 Females x Group 2 Females	SS_{bg}	1	2.3214	2.3214	.0284	4.41
	SS_{wg}	18	1469.43	81.635		
Total Males x Total Females	SS_{bg}	1	4.5529	4.5529	.7257	4.098
	SS_{wg}	39	244.6667	6.2735		
Group 1 Males x Group 2 Males x Group 2 Females x Group 1 Females	SS_{bg}	3	25.2141	8.4047	.1889	4.35
	SS_{wg}	37	1646.009	44.4867		

Chapter V

DISCUSSION AND SUMMARY

In this chapter the results of the analysis of variance (ANOVA) and correlation are discussed as they relate to the research questions and hypotheses. In Chapter Four two hypotheses were stated and tested; discussion of the tests follows.

Discussion of the Results

Hypothesis 1: H_0: There will be no significant difference in cognitive posttest scores between the two groups when feedback types are isolated and systematized. Results of the ANOVA failed to reject H_0. H_1, the motivated hypothesis is unwarranted as there was no significant difference found on posttest scores between the two groups (Table 5). This may be attributed to the fact that there was more variation within the groups than between the groups. This does not mean that feedback will not affect learning in other similar studies or learning situations. Throughout the search of the literature there is considerable support for feedback that is corrective and reinforcing.

Hypothesis 2: H_0: There will be no significant difference in cognitive post-posttest scores between the two groups (retention) when feedback types are isolated and systematized. Results of the ANOVA failed to reject H_0. H_1, the motivated hypothesis is again unwarranted as thee was no significant difference foundon post-posttest

scores between the two groups. The post-posttest was identical to the posttest and was given to measure retention. The search of the literature indicated that there is no agreement in the area of retention from CAI. The data (Table 6) do not lend support to either side of the disagreement on retention cited in Chapter Two, as feedback type did not seem to affect retention.

Post Hoc Analysis

Significant differences between the two treatment groups were not found until the groups were redefined by gender. The redefinition of the groups by gender yielded results which indicated that females of this age group who received noncorrective feedback from a CAI program scored lower on posttests than their male counterparts who received either type of feedback. Significant differences were found in posttest scores when the males who received noncorrective feedback (group two) were compared using ANOVA to the females in the same group. The male subjects had the higher scores, $F=10.1926$ $p<.01$ (Table 5). The males of group one also had significantly higher scores when compared to the group two females, $F=19.6741$, $p<.01$ (Table 5). The group two males and group one males did not reveal a significant difference even though the group one males did have the higher posttest mean.

The computer treatment took an average of 17.95 minutes for group one and 17.65 minutes for group two. From this small study we cannot tell if less time "on line" has a different impact on male students. Referring to the descriptive statistics, Tables 1 and 2, females of both groups spent more time at the computer and may have actually received more feedback. Since there was a lack of printer facilities there was no printout of each individual's treatment which

may have given more specific information as to the amount of each feedback type received.

Gender differences in the posttest scores prompt several questions about gender bias in the schools that were not the original intent of the study. Gender bias in all aspects of education is well documented, primarily in the areas of student-teacher interactions and text materials. Stockard (1980) states that "regarding acheivement boys tend to have more behaviour and learning problems in school than girls do" (p. 11). Could CAI, designed free of gender bias, be effectively utilized to reduce the learning problems so frequently experienced by males? Stockard goes on to cite six classroom studies in which males received more disapproving verbal feedback from the teacher. Stockard also mentions various theoretical research studies which suggest that learning problems of males may be the result of the type of feedback they receive. CAI has the potential to remove the personality of the teacher from instruction resulting in a more favorable learning environment for both males and females.

The standard intelligence tests show no difference between males and females since these tests are carefully constructed to delete gender bias (Stockard, 1980). Generally males seem to achieve less than their female counterparts who have similar scores, a pattern that continues until puberty. During puberty males begin to excel in math and science. Most of the testing in the present study involved computational ability, in which males of the sample population age might be expected to excel. The males' pretest scores were higher than the females' pretest scores, and although the mean posttest scores of males and females receiving corrective feedback were insignificant,

there was a significant difference in mean scores between males and females receiving non-corrective feedback. The group two females, after receiving noncorrective feedback, scored significantly lower on the posttest. Noncorrective feedback may have reinforced the "Math and science are not for me!" perception that females may have already had. It could be inferred from the present study that CAI, used appropriately, has the potential to overcome gender bias in the schools. Certainly the sex-related differential effects of various forms of feedback should be examined further.

Researchers always seek applications from their research results. This study can be used to develop and further refine existing courseware guidelines, particularly since the outcome was specific with regard to the test scores of the female subjects. It was also demonstrated that computer feedback that is noncorrective, which at times was silly or distracting, does not seem to produce greater achievement than corrective feedback. In all treatments learning did occur as demonstrated by the posttest score gains over the pretest scores. Lack of significant difference between the treatment groups does not deny the value of feedback, but suggests that the type of feedback was unimportant in this case. Therefore, these results permit CAI designers to vary feedback to keep the students' interest.

Correlations of Dependent Variables

The following is a report of correlations of the dependent variables including time, chronological age and I.Q. (Tables 7 - 11). The test score x I.Q. correlations of group two are .5747 ($p<.01$), .5282 ($p<.05$) and .2395 (NS) on respective pre-, post- and post-posttests. As could be expected, the group two subjects with

Table 7

CORRELATIONS OF VARIABLES BY GROUP

Total Sample
n=41

	Pretest	Posttest	Post-posttest	Time	Age	I.Q.	Feedback
Pretest	x	.3833*	.4209**	-.2347	-.239	-.1562	-.2095
Posttest		x	.5828**	-.2003	-.3227*	-.4001**	-.1652
Post-posttest			x	-.1703	-.4139**	.3744*	-.134
Time				x	.1113	-.332*	.0114
Age					x	-.3595*	.0969
I.Q.						x	.0007
Feedback							x

**p<.01, *p<.05

Table 8

CORRELATIONS OF VARIABLES BY GROUP

Treatment Group One
n=21

	Pretest	Posttest	Post-posttest	Time	Age	I.Q.
Pretest	x	.1929	.4086	-.3449	.0833	-.2071
Posttest		x	.6829**	-.338	-.1423	.1911
Post-posttest			x	-.4178	-.1305	.2595
Time				x	-.1009	.0106
Age					x	-.7867**
I.Q.						x

Treatment Group Two
n=20

	Pretest	Posttest	Post-posttest	Time	Age	I.Q.
Pretest	x	.6539**	.4066	-.1755	-.1201	.5747**
Posttest		x	.4542*	-.0923	-.22996	.5282*
Post-posttest			x	.0102	-.3815	.2395
Time				x	.1069	-.375
Age						x
I.Q.						

**p<.01, *p<.05

Table 9

CORRELATIONS OF VARIABLES BY GENDER

Females, Group One
n=13

	Pretest	Posttest	Post-posttest	Time	Age	I.Q.
Pretest	x	-.0699	.255	-.3599	-.168	-.3538
Posttest		x	.7429**	-.0394	.2489	.2824
Post-posttest			x	-.1164	.2144	.284
Time				x	-.1645	.101
Age					x	.4522
I.Q.						x

Females, Group Two
n=7

	Pretest	Posttest	Post-posttest	Time	Age	I.Q.
Pretest	x	.8408*	.8917**	.5597	-.5271	.0003
Posttest		x	.6327	.6605	-.1627	.2044
Post-posttest			x	.2127	-.4596	-0009
Time				x	-.1844	-.2977
Age					x	.4629
I.Q.						x

**p<.01, *p<.05

Table 10

CORRELATIONS OF VARIABLES BY GENDER

Males, Group One
n=8

	Pretest	Posttest	Post-posttest	Time	Age	I.Q.
Pretest	x	.4866	.5152	-.2443	-.332	.2717
Posttest		x	.5383	-.1547	-.2457	-.1697
Post-posttest			x	-.7918*	-.7949*	.5584
Time				x	.7565*	-.5516
Age					x	-.3824
I.Q.						x

Males, Group Two
n=13

	Pretest	Posttest	Post-posttest	Time	Age	I.Q.
Pretest	x	.7183**	.3095	-.3734	-.0261	.6797*
Posttest		x	.3426	-.1358	-.0701	.4039
Post-posttest			x	-.0261	-.3175	.25099
Time				x	.1217	-.5168
Age					x	-.4803
I.Q.						x

**p<.01, *p<.05

Table 11

CORRELATIONS OF VARIABLES BY GENDER

Males, Both Groups
n=21

	Pretest	Posttest	Post-posttest	Time	Age	I.Q.
Pretest	x	.6014**	.439	-.3457	-.1948	.514
Posttest		x	.4502*	-.1698	-.1981	.2855
Post-posttest			x	-.2567	-.518	.4108
Time				x	.2756	-.5055*
Age					x	-.4515*
I.Q.						x

Females, Both Groups
n=20

	Pretest	Posttest	Post-posttest	Time	Age	I.Q.
Pretest	x	.1497	.3732	-.1492	-.2249	-.2874
Posttest		x	.7326**	.1449	.0987	.3011
Post-posttest			x	.0317	.0699	.2046
Time				x	-.1497	-.0317
Age					x	.4148
I.Q.						x

**p<.01, *p<.05

with the higher I.Q.s scored higher on the tests (Table 8). There was a negative, nonsignificant correlation between the pretest and I.Q. in group one signifying that the subjects with the higher I.Q.s did not score as well as subjects with lower I.Q.s on the pretest only. The other two correlations were positive.

The significant correlation of the post-posttest with time spent "on line" was negative for the treatment group one males, -.7918 ($p<.05$). The post-posttest x age was significant in the total sample, -.4139 ($p<.01$) and the males of group one, -.7949 ($p<.05$). The group one males were younger, spent less time "on line" and still received higher scores. The post-posttest x I.Q. correlation was significant in the total sample, .3744 ($p<.05$), meaning higher I.Q. students had higher test scores.

Other significant correlations were found between I.Q. and the following variables. Age x I.Q.: significance was found at the .01 level for treatment group one, -.7867. For the total sample correlation of -.3595 and total males x I.Q. x age a correlation of -.4515 ($p<.05$) was found. The younger subjects in the study had the higher I.Q.s, indicating a biased sampling due to the nature of the study hall population. Time "on line" x I.Q.: ($p<.05$) was found for Treatment Two, Total Sample and Total Males with correlations of -.5009, -.332 and -.5055, respectively. Those students spending less time at the microcomputer received higher test scores. Again, this could be due to biased sampling that was entirely unintentional.

Recommendations for Further Research

The present study raised more questions than it answered. Continuation of this study is recommended utilizing:

1. greater numbers of subjects,
2. samples representing different ages and grade levels,
3. screening subjects according to degree of computer proficiency,
4. feedback types that are more highly refined than those used in the present study,
5. printers to record the amount of feedback actually received by the subjects.

It is also recommended that a similar study be done that involves a measure of attitude. Educators need to know whether or not students will feel favorably about the content area if learning is computerized. A study relating attitudes with type of feedback should also be considered. Finally, subsequent treatment effects should include I.Q. and other correlates identified here as part of the experimental design to permit application of these controls to others who may pursue this line of research.

Summary

Even though the null hypotheses were retained and significant differences of post- and post-posttest scores between treatment groups were not found by ANOVA, there was a pattern of significance when the groups were redefined by gender. As the need for the present study was defined, it was stated that there is a lack of evidence for the feedback type recommended by the authors of the literature

(Chapter Two). The present study does not help the case of those authors. The males of treatment group one, who received corrective feedback, scored higher on the posttest but not significantly higher than the males who received non-corrective feedback.

The fact that the group two females had significantly lower posttest scores when compared to the male subjects from either treatment group (Table 5) again reflects a potential gender bias in the schools. Females of High School age traditionally do not do as well in science and math, consequently they tend to take less of those subjects (Stockard, 1980). This may be due partly to the fact that females perceive science and math as masculine subjects (Stockard, 1980). Differences in math achievement scores are not as marked as they used to be in this country (Stockard, 1980); differences in test scores and attitudes still do exist.

The treatment received by students in this study did indeed have an impact on their posttest performance. In light of the potential to highly individualize education using microcomputers, education is expected to become increasingly diagnostic and prescriptive. Close attention needs to be paid to the type of feedback the students receive since this is related to their learning. Since research supports the existence of gender bias in our educational system, CAI might be effectively used to overcome this bias by removing the personality of the teacher from instruction, therefore removing gender bias from the schools. Consequently the future of CAI may be the realization of educational equity for all students.

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APPENDICES

Appendix A

SAMPLE RUN OF BOTH COMPUTER TREATMENTS

CORRECTIVE TREATMENT

Sample Run

This is a review of information from this program

Type the number of your answer choice after you read the questions and choices

Press space bar to go on

In the formula C=5/9(F-32) the C represents

1. The original temp in Centigrade
2. Original temp Fahrenheit
3. Converted temp from C to F
4. Converted temp from F to C

Please type the number of your answer

2

No. C means Centigrade. Try again

In the formula C=5/9(F-32) the C represents

1. The original temp in Centigrade
2. Original temp Fahrenheit
3. Converted temp from C to F
4. Converted temp from F to C

Please type the number of your answer

3

Close, but try reading the problem again

In the formula C=5/9(F-32) the C represents

1. The original temp in Centigrade
2. Original temp Fahrenheit
3. Converted temp from C to F
4. Converted temp from F to C

Please type the number of your answer

4

Nice!

In the U.S. Centigrade is commonly used for:

1. Cooking and baking
2. Weather reports
3. Medicine and sciences

Type the number of your answer

1

No. Think about it again

In the U.S. Centigrade is commonly used for:

1. Cooking and baking
2. Weather reports
3. Medicine and sciences

Type the number of your answer

3

Way to go, Jane!

Use the formula F=9/5 C+32 for this:

You want to bake a pie and have a Centigrade thermometer. It reads 200. What is the equivalent on the Fahrenheit scale?

1. 375 F
2. 392 F
3. 400 F
4. 425 F

Type the number of your answer

1

No. Try a higher temperature

Use the formula F=9/5 C+32 for this:

You want to bake a pie and have a Centigrade thermometer. It reads 200. What is the equivalent on the Fahrenheit scale?

1. 375 F
2. 392 F
3. 400 F
4. 425 F

Type the number of your answer

2

Very good! Do you wish to see any of this again?

Type yes or no

No

Good-bye, Jane!

NONCORRECTIVE FEEDBACK

Sample Run

This is a review of information from this program

Type the number of your answer choice after you read the questions and choices

Press space bar to go on

In the formula C=5/9(F-32) the C represents

1. The original temp in Centigrade
2. Original temp Fahrenheit
3. Converted temp from C to F
4. Converted temp from F to C

Please type the number of your answer

4

Nice!

Water boils at:

1. 37 C or 98.6 F
2. 0 C or 32 F
3. 100 C or 212 F

Please type the number of your answer

2

No. That's not using your noodle!

Water boils at:

1. 37 C or 98.6 F
2. 0 C or 32 F
3. 100 C or 212 F

Please type the number of your answer

1

No. Ten lashes with a wet spaghetti!

Water boils at:

1. 37 C or 98.6 F
2. 0 C or 32 F
3. 100 C or 212 F

Please type the number of your answer

3

Nice, Kelly!

In the formula C=5/9(F-32) The F represents

1. The converted temp in F
2. The original temp in C
3. The original temp in the problem

Please type the number of your answer

1

No way!

In the formula C=5/9(F-32) the F represents:

1. The converted temp in F
2. The original temp in C
3. The original temp in the problem

Please type the number of your answer

3

Super! You understand!

In the U.S. Centigrade is commonly used for

1. Cooking and baking
2. Weather reports
3. Medicine and science

Type the number of your answer

2

No, not even on a rainy day!

In the U.S. Centigrade is commonly used for:

1. Cooking and baking
2. Weather reports
3. Medicine and science

Type the number of your answer

1

No. You get a burnt cookie!

In the U.S. Centigrade is commonly used for:

1. Cooking and baking
2. Weather reports
3. Medicine and science

Type the number of your answer

3

Way to go, Kelly!

Centigrade is used by:

1. All countries but the U.S.
2. Only the U.S., no others
3. Only England

Type your answer's number

1

Good answer

Normal human temp is:

1. 20 C
2. 37 C
3. 100 C

Type the number of your answer

1

Wrong. You won a trip to Tyrone!

Use the formula C=5/9(F-32)

You are traveling in Canada and need to know what a normal room temp of 68 F is equal to in Centigrade

1. 32 C
2. 50 C
3. 70 C
4. 20 C

Type your answer's number

2

You loose, Cookie!

Use the formula C=5/9(F-32)

You are traveling in Canada and need to know what a normal room temp of 68 F is equal to in Centigrade

1. 32 C
2. 50 C
3. 70 C
4. 20 C

Type your answer's number

2

You loose, Cookie!

Use the formula C=5/9(F-32)

You are traveling in Canada and need to know what a normal room temp of 68 F is equal to in Centigrade

1. 32 C
2. 50 C
3. 70 C
4. 20 F

Type your answer's number

2

You loose, Cookie!

Use the formula C=5/9(F-32)

You are traveling in Canada and need to know what a normal room temp of 68 F is equal to in Centigrade

1. 32 C
2. 50 C
3. 70 C
4. 20 F

Type your answer's number

4

Good! You really know how to use the formula!

Appendix B

TESTING INSTRUMENTS

PRE-TEST Do not write your name!

Directions: Write the letter of your answer in the column on the left. There is no penalty for guessing. Do calculations on the test.

_____ 1. The Centigrade scale is predominately used to measure temperature

a. only in the Netherlands
b. only European countries
c. everywhere but the United States
d. all but the U.S.S.R. and Poland

_____ 2. When cooking or baking in the United States you use the

a. Fahrenheit scale
b. Kelvin scale
c. Centigrade scale
d. Absolute scale

_____ 3. Which temperature scale is not part of the metric system?

a. Centigrade
b. Kelvin
c. Absolute
d. Fahrenheit

Use the formula C=5/9(F-32) for the following questions: Choose the answer closest to your own.

_____ 4. The equivalent to 50° F is

a. 20° C
b. 30° C
c. 10° C
c. 15° C

_____ 5. You are visiting Mexico and need to find the equivalent to 75° F. The answer is approximately:

a. 10° C
b. 24° C
c. 54° C
d. 62° C

_____ 6. You are traveling in France and feel sick. According to the Centigrade thermometer available to you, your temperature is 37° C. Knowing that the normal temperature is 98.6° F, you calculate that your temperature is:

a. below normal
b. above normal
c. normal
d. not significant on the Centigrade scale

Use the formula F=9/5 C+32 for questions 7, 8 and 9: Choose the answer closest to your own.

_____ 7. If the temperature is 30° C on a hot December day in New Zealand, what is the equivalent temperature in Fahrenheit?

a. 68° F
b. 78° F
c. 88° F
d. 98° F

_____ 8. You are measuring the oven temperature with a Centigrade thermomenter. The oven needs to be 375° F to bake cookies. Your Centigrade thermometer reads 190.5°. The oven is

a. too hot to bake cookies
b. exactly right for the cookies
c. not hot enough to bake cookies
d. is too high for the Fahrenheit scale

_____ 9. Your temperature is 40° C. What is its equivalent on the Fahrenheit scale?

a. 99° F
b. 101° F
c. 104° F
d. 105° F

For questions 10, 11 and 12 follow these directions:

first - draw a line connecting temperatures that correspond on the two scales between the right and left columns

second - mark the formula that you would use to make the conversion from the left to the right column's temperature

write an A if you use F=9/5 C+32
write a B if you use C=5/9(F-32)

		39° C
_____	10. 0° C	212° F
_____	11. 98.6° F	32° F
_____	12. 100° C	37° C
		-17° F

POST-TEST Do not write your name!

Multiple choice: write the letter of your answer in the column on the left. There is no penalty for guessing. Do calculations on the test.

_____ 1. Which scale is commonly used to measure temperature in most countries but not the United States?

a. Kelvin
b. Absolute
c. Fahrenheit
d. Centigrade

_____ 2. If you are cooking or baking in the United States you are using the

a. Absolute scale
b. Fahrenheit scale
c. Centigrade scale
d. Kelvin scale

_____ 3. Which temperature is not part of the metric system?

a. Kelvin
b. Absolute
c. Fahrenheit
d. Centigrade

Use the formula C=5/9(F-32) for the following questions: Choose the answer closest to your own.

_____ 4. The equivalent to 40° F is:

a. 100° C
b. 0° C
c. 4° C
d. 50° C

_____ 5. You are visiting Mexico and need to find the equivalent to 68° F. The answer is:

a. 32° C
b. 50° C
c. 70° C
d. 20° C

_____ 6. You are traveling in France and feel sick. According to the Centigrade thermometer available there your temperature is 38° C. Knowing that normal temperature Fahreheit is 98.6°, you realize that your temperature is:

a. below normal
b. normal
c. above normal
d. not significant on the Fahrenheit scale

Use the formula F=9/5 C+32 for the following questions, 7, 8 and 9: Choose the answer closest to your own.

_____ 7. If the temperature is 10° C on a Spring Day in New Zealand, what is the equivalent temperature in Fahrenheit?

a. 20° F
b. 30° F
c. 40° F
d. 50° F

_____ 8. You are measuring the oven temperature with a Centigrade thermometer. The oven needs to be 325° F to bake your cake. Your Centigrade thermometer reads 162.5°. The oven is

a. Too hot to bake the cake
b. exactly right to bake the cake
c. not enough to bake your cake
d. is too high for the Centigrade scale

_____ 9. Your temperature is 39° C. What is its equivalent on the Fahrenheit scale?

a. 98.2° F
b. 101.2° F
c. 102.2° F
d. 104° F

For 10, 11 and 12 follow these directions:

first - draw a line connecting temperatures that correspond on the two scales between the right and left columns

second - mark the formula you would use to make the conversion from the left to the right column's temperature

write an A if you use C=5/9(F-32)
write a B if you use F=9/5 C+32

		39° C
_____	10. 100° C	
		32° F
		212° F
_____	11. 98.6° F	
_____	12. 0° C	-17° F
		37° F

Answer Keys

QUESTION	POSTTEST	PRETEST
1	D	C
2	B	A
3	C	D
4	C	C
5	D	B
6	C	C
7	D	C
8	B	A
9	C	D
10	B	A
11	A	B
12	B	A

Appendix C

INFORMED CONSENT FORM

and

INSTRUCTIONS TO SUBJECTS

INFORMED CONSENT FORM

The Pennsylvania State University

Title of Investigation: Effectiveness of Computer Feedback

Investigators: Carol L. Hodes, graduate student
Dr. Paul Bell, Professor of Education

Date: September 20, 1983

This is to certify that I, _____, hereby give permission to have my child participate as a volunteer in a scientific study as an authorized part of the Education and Research program of the Pennsylvania State University under the supervision of Dr. Paul Bell.

The investigation and my child's part in the investigation have been defined and fully explained to me by the researcher, Carol Hodes, on the attached sheet, and I understand her explanation. A copy of the procedures of this investigation and a description of any risks or discomforts has been provided to me and has been discussed in detail.

I have been given the opportunity to ask whatever questions I may have had and all such questions and inquiries have been answered to my satifsfaction (An explanation of the study is attached.)

I understand that any data or answers to questions will remain confidential with regard to the child's identity.

I further understand that I am free to withdraw my consent and terminate my child's participation at any time.

I hereby consent to the participation of _____, as a minor, as a subject in the scientific investigation described.

_____ _____
date Signature of parent or guardian

I, the undersigned, have defined and fully explained the investigation to the above subject and parent or guardian.

_____ _____
date Investigator's signature

EXPLANATION OF STUDY

Purpose of Study:

The purpose of this study is to attempt to develop guidelines for computer software for the State College School District. As computer software is developed and considered for purchase criteria need to be established in order to make efficient use of our tax dollars and the student's time. Thus there is a direct benefit to both the student and parent.

Procedures to be Followed:

This study involves the students and the school's micro-computers. The procedures are:

1. Normal school routine will not be interrupted as the study is to be carried out in an established educational setting. Students will be removed from study hall for a short period of time to participate, approximately a half hour. There are no risks to the student.
2. This study is being done with full approval of the Administration of the School District and has been considered mutually beneficial.
3. This study involves normal educational practices with which the students are familiar:
    a. multiple choice pre- and posttests to be taken on paper
    b. an instructional computer program concerning metric conversion which is similar in format to currently marketed computer software.

Alternative Procedures:

If the student does not participate, he or she will simply remain in study hall with the regularly assigned teacher. There will be no pressure to participate and no penalty of any sort for choosing not to participate.

Contact Person:

If there are any questions as to the intent of this study, please leave a message at the Intermediate High School (238-8451) and the researcher will return your call:

Carol Hodes, Intermediate High School
650 Westerly Parkway, State College, Pa. 16801

Subject's signature	date	Investigator	date

Parent or guardian signature	date

DIRECTIONS TO THE SUBJECT

Before beginning the computer treatment, the subjects are to receive this explanation:

1. You will follow directions given by the computer during this computer program on the use of temperature scales Centigrade and Fahrenheit

2. You will be expected to complete all 5 parts listed on the main menu

3. You will have the opportunity to return to any part of the program you wish to see again

4. Proceed at your own pace. At certain points you can press the space bar to go on, at other times the computer will wait for you to type in an answer

5. When taking the test afterwards, be certain not to write your name on it, you may write calculations in the margins if you wish.